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## (54) Rubber composition for tyre treads

(57) A rubber composition suitable for use in tread of tyres having improved rolling characteristics without deteriorating wet grip characteristics, which comprises a rubber component containing a diene rubber and 5 to 25 parts by weight of a halogenated copolymer of isobutylene and p-methylstyrene, and 30 to 90 parts by weight of carbon black, respectively, per 100 parts by weight of the rubber component, the rubber composition having a tan δ max temperature of not more than - 15°C.

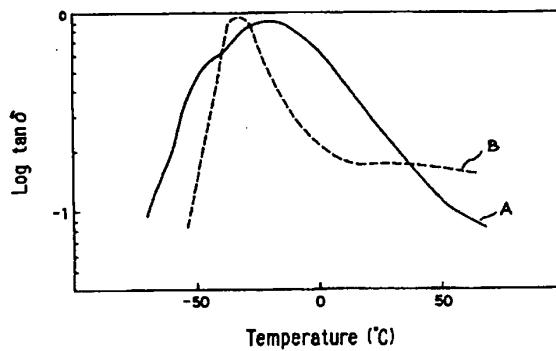


FIG. 1

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**Description**

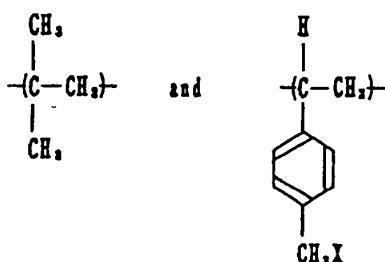
- The present invention relates to a rubber composition suitable for use in tyre treads, and more particularly to a rubber composition for tyre treads having reduced rolling resistance and improved wet grip.
- In recent years, from the viewpoint of accommodating social demands to save resources and energy, development of so-called low fuel cost tyres has been pursued extensively in order to save fuel costs of automobiles. The lower the rolling resistance of tyres is made, the more the fuel consumption of automobiles is decreased, thus providing low fuel cost tyres. Accordingly, it is necessary to use, as a tread rubber, rubber compositions having a low rolling resistance, namely a low hysteresis loss.
- On the other hand, tread rubbers having a large frictional resistance on wet roads are desirable from the viewpoint of safety in running.
- Accordingly, the frictional resistance on wet roads must be increased for raising the wet grip force, while rolling resistance must be decreased for achieving a low fuel cost. Thus, both the rolling property and the wet grip property are in a contradictory relationship to each other. Various compositions for tyre treads have hitherto been proposed in order to satisfy both properties simultaneously.
- For instance, proposals have been made in view of the fact that rubber polymers and carbon black greatly affect these properties. In the case of using a styrene-butadiene copolymer as a rubber polymer, it has been proposed to improve both the rolling property and the wet grip property by suitably selecting the content of bound styrene and the content of 1,2-bonds in the butadiene portion. With respect to carbon black, from the viewpoint that the cut chipping resistance of treads deteriorates if the particle size is large or the amount is small, carbon black of a new type having an improved degree of surface activity of carbon black particle, e.g. carbon black N351, has been developed. An effect has been achieved thereby to some extent.
- However, tyres having a further improved rolling property are desired to meet the demand of energy saving.
- It is an object of the present invention to provide a rubber composition for tyre treads, which is further decreased in rolling resistance without deteriorating the wet grip property.
- This and other objects of the present invention will become apparent from the description hereinafter.
- The rolling resistance and friction coefficient of tyres on wet roads both have a relationship to the viscoelasticity of rubber compositions. In details, rolling resistance is related to the loss coefficient at a temperature in the vicinity of 50°C, and wet grip force is related to the loss coefficient at a temperature in the vicinity of 0°C.
- It has been found that the temperature dependency of the loss coefficient of a rubber composition can be changed by adding a specific polymer to the composition, whereby rolling property and the wet grip property of the tyre can both be improved.
- In accordance with the present invention, there is provided a rubber composition for a tyre tread, comprising a rubber component containing a diene rubber and 5 to 25 parts of a halogenated copolymer of isobutylene and p-methylstyrene, and 30 to 90 parts of carbon black, said parts all being parts by weight per 100 parts by weight of said rubber component, the tan δ max temperature of the cured product of said rubber composition being not more than -15°C.
- Since a rubber having a specific structure, namely a halogenated copolymer of isobutylene and p-methylstyrene, the peak of loss coefficient of which is broad and extends up to a relatively high temperature region, is incorporated in the rubber composition with usual diene rubbers, the loss coefficient is large in the vicinity of 0°C and is small in the vicinity of 50°C as compared with rubber compositions containing conventionally used usual diene rubbers alone as a rubber component. Thus, the rolling characteristics and the wet grip characteristics which are contrary to each other, can be improved to reduce the rolling resistance and to increase the friction resistance on wet roads. The tread rubber composition of the present invention thus provides low fuel cost tyres having excellent wet grip characteristics.
- The accompanying drawing shown in Figure 1 is a graph showing isochronal temperature sweeps of the loss coefficients of a halogenated copolymer of isobutylene and p-methylstyrene and an emulsion-polymerised SBR where in the solid line A shows the temperature dependency for the halogenated copolymer and the broken line B shows the temperature dependency for SBR.
- One or more of the diene rubbers which have been conventionally used in tyre production, e.g. natural rubber (NR), isoprene rubber (IR), styrene butadiene rubber (SBR) and butadiene rubber (BR), can be used in the present invention.
- A solution-polymerised SBR and an emulsion-polymerised SBR are preferably used among the diene rubbers, since the solution-polymerised SBR gives a rubber having a high impact resilience and a low energy loss and makes it easy to prepare rubber compositions in compliance with purposes and since the emulsion-polymerised SBR is superior in low cost, processability and strength.
- From a connection with a halogenated copolymer of isobutylene and p-methylstyrene, it is desirable to select a diene rubber, the peak temperature of the loss coefficient (tan δ max temperature) of which is not more than -25°C.
- The term "peak temperature" as herein used means a temperature corresponding to the top of a peak (tan δ max).
- The diene rubbers are used in combination with a halogenated copolymer of isobutylene and para-methylstyrene (hereinafter referred also to as "methylstyrene copolymer rubber") as a rubber component of the composition according to the present invention. The content of p-methylstyrene in the copolymer is not more than 20% by weight, preferably

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not more than 10% by weight, and is not less than 2% by weight. If the p-methylstyrene content is more than 20% by weight, the viscosity of the copolymer is raised, thus resulting in decrease of the processability. This copolymer is obtained by halogenating an isobutylene/p-methylstyrene copolymer, whereby the p-methylstyrene portion is halogenated. Thus it contains the isobutylene units and the halogenated p-methylstyrene units shown by the following formulas:

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wherein X is a halogen atom such as chlorine or bromine.

The degree of halogenation (the content of a halogen) is from about 1% to about 10% by weight, preferably from about 1% to about 5% by weight, typically about 2% by weight.

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As shown in the accompanying drawing of Figure 1 wherein the solid line A shows a temperature dependency of the loss coefficient of the methylstyrene copolymer rubber and the broken line B shows a temperature dependency of the loss coefficient of an emulsion-polymerised SBR ("SBR 1500" made by Sumitomo Chemical Company Limited) which is a representative usual diene rubber, the peak of the loss coefficient of the methylstyrene copolymer rubber is broad as compared with the emulsion-polymerised SBR and extends up to a relatively high temperature side. Moreover, the loss coefficient thereof is lower than that of the SBR at the higher temperature side. The rubber compositions used in the measurement of loss coefficient are shown in the following Table 1.

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TABLE 1

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Composition	Solid line A of Fig. 1	Broken line B of Fig. 1
Methylstyrene copolymer rubber*	100	-
Emulsion-polymerised SBR	-	100
Carbon black N339	40	40
Wax	2	2
Antioxidant	2	2
Stearic acid	2	2
Zinc oxide	2	2
Sulfur	-	1.5
Curing accelerator	-	0.75

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(Note) \*Halogenated copolymer of isobutylene and p-methylstyrene commercially available under the trade mark "EXXPRO" 90-10 made by Exxon Corp.

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Since the methylstyrene copolymer rubber has such loss coefficient characteristics, the temperature dependency of the loss coefficient of a rubber composition can be changed so as to raise the loss coefficient at a temperature in the vicinity of 0°C and to lower the loss coefficient at a temperature in the vicinity of 50°C by using a diene rubber which has the loss coefficient peak on a low temperature side, in combination with the methylstyrene copolymer rubber. Thus, it is possible to satisfy both the rolling characteristics and the wet grip characteristics which are contrary to each other. Since these effects are based on utilisation of a difference in the temperature dependency of loss coefficient between

the diene rubber and the methylstyrene copolymer rubber, it is preferable, as mentioned above, that the loss coefficient peak temperature ( $\tan \delta$  max temperature) of the diene rubber is not higher than -25°C.

The methylstyrene copolymer rubber is used in an amount of 5 to 25 parts by weight, preferably 5 to 20 parts by weight, per 100 parts by weight of the rubber component, namely per 100 parts by weight of all rubbers used. If the amount of the methylstyrene copolymer rubber is less than 5 parts by weight, effects of improvement in the rolling resistance and the friction resistance on wet roads are not observed. If the amount of the methylstyrene copolymer is more than 25 parts by weight, lowering of the abrasion resistance becomes marked and also the processability is deteriorated.

It is preferable to incorporate 30 to 90 parts by weight of carbon black per 100 parts by weight of the rubber component into the rubber composition according to the present invention. If the amount of carbon black is less than 30 parts by weight, the abrasion resistance is deteriorated. If the amount is more than 90 parts by weight, improvement effects on rolling and wet grip characteristics are reduced. The kind of carbon black is not particularly limited.

The rubber composition of the present invention can contain various additives for rubbers as generally used, e.g. a curing agent such as sulfur, a curing accelerator, an activator such as zinc oxide or stearic acid, a process oil, an antioxidant, a filler and other additives.

The rubber composition of the present invention can be prepared and cured conventionally.

It is preferable that the cured product obtained by curing the rubber composition of the present invention has a  $\tan \delta$  max temperature of not more than -15°C, since improvement effects on rolling characteristics and wet grip characteristics are clearly observed.

The  $\tan \delta$  max temperature as herein used is determined from a curve of change in loss tangent ( $\tan \delta$ ) with respect of temperature measured using a viscoelasticity spectrometer under conditions of frequency 10 Hz, initial strain 10%, amplitude 0.5% and rate of temperature elevation 2°C/minute.

The present invention is more specifically described and explained by means of the following Examples and Comparative Examples in which all parts are by weight. It is to be understood that the present invention is not limited to the Examples.

#### Examples 1 to 3 and Comparative Examples 1 to 6

Nine rubber compositions A-1 to D-2 were prepared according to the recipes shown in Table 2, wherein rubber compositions shown by the same alphabet number had the same composition of components other than the rubber component, by mixing the components other than sulfur, accelerator, antioxidant and zinc oxide at 150°±5°C to give a first stock and then mixing the first stock with sulfur, accelerator, antioxidant and zinc oxide at 110°±10°C to give a final stock.

Rubber compositions A-1, B-1 and C-1 containing no methylstyrene copolymer rubber, rubber composition D-1 and D-2 containing a large amount of carbon black, and rubber composition C-2 which contains a methylstyrene copolymer rubber, but whose cured product has a  $\tan \delta$  max temperature of more than -15°C, are for comparative example, whilst rubber compositions A-2, B-2 and C-3 are examples of the present invention.

The components shown in Table are as follows:

Methylstyrene copolymer: Halogenated copolymer of isobutylene and p-methylstyrene commercially available under the trade mark "EXXPRO" 90-10 made by Exxon Corp.

Emulsion SBR (1): Emulsion-polymerised styrene-butadiene rubber having a bound styrene content of 23.5% by weight and a vinyl bond content of 18.0% by weight commercially available under the trade mark "SBR 1500" made by Sumitomo Chemical Company Limited.

Emulsion SBR (2): Oil extended emulsion-polymerised styrene-butadiene rubber having a bound styrene content of 35.0% by weight, a vinyl bond content of 18.0% by weight and an oil extender content of 37.5 parts per 100 parts of the rubber commercially available under the trade mark "SBR 9520" made by Nippon Zeon Co Limited.

Solution SBR: Solution-polymerised styrene-butadiene rubber having a bound styrene content of 21.0% by weight and a vinyl bond content of 63.0% by weight commercially available under the trade mark "NS 116" made by Nippon Zeon Co Limited.

Carbon black: N220 and N339 made by Showa Cabot Kabushiki Kaisha.

Antioxidant: N-Phenyl-N'-(1,3-dimethylbutyl)-p-phenylenediamine

Curing accelerator: N-Tert-butyl-2-benzothiazolylsulfenamide.

In Table 2, the amount of oil shows that of the oil added in order to adjust the hardness of a finally obtained rubber and except the amount of the oil extender included in the oil extended rubber.

The thus prepared rubber compositions were evaluated as follows:

The prepared rubber compositions were press-cured at 170°C for 12 minutes to give cured rubber specimens. Loss tangent ( $\tan \delta$ ) dispersion curves of the specimens were measured by a viscoelasticity spectrometer made by Iwamoto Seisakusho Kabushiki Kaisha under conditions of frequency 10 Hz and amplitude 0.5%. From the obtained results, the  $\tan \delta$  peak temperature was measured. Also, the  $\tan \delta$  values at 0°C and 50°C were obtained, and the  $\tan \delta$  values of

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a composition containing the methylstyrene copolymer at 0°C and 50°C were represented as an index to the tan δ values of the corresponding composition containing no methylstyrene copolymer regarded as 100.

Also, abrasion resistance of the cured rubber specimens was measured using a Lambourn abrasion tester made by Iwamoto Seisakusho Kabushiki Kaisha under conditions of loading 2.5kg and slip percentages 20% and 40%. The average of the abrasion values under slipping conditions 20% and 40% was obtained, and the average value for a composition containing the methylstyrene copolymer was represented as an index to the average value for the corresponding composition containing no methylstyrene copolymer regarded as 100. The larger the abrasion index, the better is the abrasion resistance.

The results are shown in Table 2.

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Table 2

	Com. Ex.1	Ex.1	Com. Ex.2	Ex.2	Com. Ex.3	Com. Ex.4	Ex.3	Com. Ex.5	Ex.6
Composition No.	A-1	A-2	B-1	B-2	C-1	C-2	C-3	D-1	D-2
Rubber component									
Methylstyrene copolymer	0	15	0	15	0	15	15	0	15
Emulsion SBR (1)	100	85	80	65	-	-	-	-	-
Emulsion SBR (2)	-	-	-	-	-	-	-	137.5	117
Solution SBR	-	-	-	-	50	35	50	-	-
Butadiene rubber	-	-	20	20	-	-	-	-	-
Natural rubber	-	-	-	-	50	50	35	-	-
Carbon black	65	65	65	65	-	-	-	100	100
N339	-	-	-	-	55	55	55	-	-
Oil	15	15	15	15	15	15	15	20	25.5
Stearic acid	2	2	2	2	2	2	2	2	2
Zinc oxide	2	2	2	2	2	2	2	2	2
Wax	2	2	2	2	2	2	2	2	2
Antioxidant	2	2	2	2	2	2	2	2	2
Curing accelerator	1	1	1	1	1	1	1	1	1
Sulfur	1.5	1.5	1.5	1.5	1.8	1.8	1.8	1.5	1.5
Tan δ max temperature (°C)	-30	-29	-37	-34	-18	-13	-18	-18	-16
Tan δ index at 0°C	100	130	100	124	100	130	115	100	100
Tan δ index at 50°C	100	86	100	95	100	106	92	100	96
Abrasion index	100	90	100	95	100	100	90	100	80

50 It can be seen in Table 2 that in any of the combinations in the rubber compositions A to D, rubber compositions containing the methylstyrene copolymer rubber have an increased tan δ index at 0°C and a decreased tan δ index at 55 50°C as compared with rubber compositions containing no methylstyrene copolymer rubber. It would be understood therefrom that both the rolling characteristics and the wet grip characteristics can be improved by the incorporation of the methylstyrene copolymer rubber. However, if the amount of carbon black incorporated is too large, the tan δ values do not change or sufficiently change both at 0°C and 50°C, particularly at 0°C, as apparent from the results of the compositions D, and accordingly desirable improvements in rolling and wet grip characteristics are hard to obtain.

55 Also, it can be seen from the results of Comparative Example 4 (rubber composition C-2) that even if a rubber composition is incorporated with the methylstyrene copolymer, the rolling characteristics are deteriorated if the tan δ max temperature of the composition is higher than -15°C, so the object of the present invention cannot be achieved.

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The abrasion resistance of the compositions of Examples 1 to 3 is still satisfactory.

In addition to the ingredients used in the Examples, other ingredients can be used in the Examples as set forth in the specification to obtain substantially the same results.

**5 Claims**

1. A rubber composition for a tyre tread, characterised by a rubber component containing a diene rubber and 5 to 25 parts of a halogenated copolymer of isobutylene and p-methylstyrene, and 30 to 90 parts of carbon black, said parts all being parts by weight per 100 parts by weight of said rubber component, the tan δ max temperature of the cured product of said rubber composition being not more than -15°C.  
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2. A rubber composition according to claim 1, characterised in that said diene rubber is at least one member selected from the group consisting of natural rubber, isoprene rubber, butadiene rubber and styrene-butadiene rubber.  
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3. A rubber composition according to claim 2, characterised in that said diene rubber contains an emulsion-polymerised styrene-butadiene rubber.  
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4. A rubber composition according to claim 2, characterised in that said diene rubber contains a solution-polymerised styrene-butadiene rubber.  
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5. A rubber composition according to any of claims 1 to 4, characterised in that said diene rubber has a tan δ max temperature of not more than -25°C.  
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6. A rubber composition according to any of claims 1 to 5, characterised in that said halogenated copolymer of isobutylene and p-methylstyrene has a p-methylstyrene content of at most 20% by weight.  
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7. A rubber composition according to any of claims 1 to 6, characterised in that said rubber component contains 5 to 20% by weight of said halogenated copolymer of isobutylene and p-methylstyrene.  
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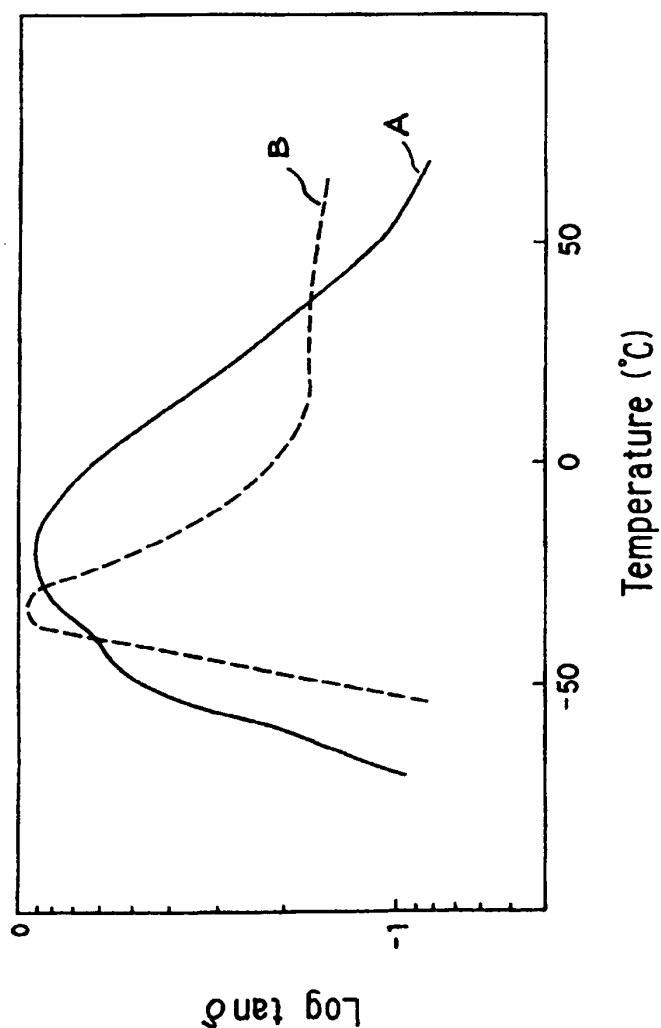
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FIG. 1





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-5 063 268 (YOUNG DONALD G) 5 November 1991 * column 6, line 59 - line 62; claims * ---	1-7	C08L21/00 B60C1/00
X	US-A-5 162 409 (MROCZKOWSKI TOMASZ S) 10 November 1992 * column 4, line 39 - line 43; claims * -----	1-7	
TECHNICAL FIELDS SEARCHED (Int.Cl.6)			
C08L B60C			
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	18 March 1996	Van Humbeeck, F	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
<small>EPO FORM 1501/02 (PCT/02)</small>			